DT

(12) UK Patent Application (19) GB (11) 2 243 213 (13) A

(43) Date of A publication 23.10.1991

(21) Application No 9105222.5

(22) Date of filing 12.03.1991

(30) Priority data
(31) 9007906 (32) 06.04.1990 (33) GB

(71) Applicant
United Kingdom Atomic Energy Authority
(Incorporated in the United Kingdom)
11 Charles II Street, London, SW1Y 4QP, United Kingdom

(72) Inventors
David MacAlpine Livesley
George Cooper

(74) Agent and/or Address for Service
Peter Turquand Mansfield
United Kingdom Atomic Energy Authority,
Patents Branch, Building 329, Harwell Laboratory,
Oxfordshire, OX11 0RA, United Kingdom

(51) INT CL^5
G01N 15/00

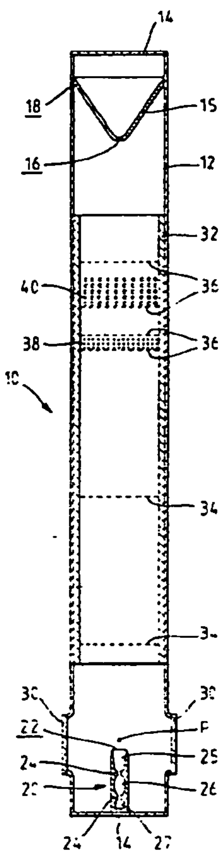
(52) UK CL (Edition K)
G1A AA2 AA3 AFB AG1 AG13 AG2 AG7 AP1 AR7 AS4 AT14 AT22 AT3 AT7 AT8

(56) Documents cited
GB 2073412 A
Particle Characterization, Vol. 4, No. 4 pp 157-65 (Dec. 1987)

(58) Field of search
UK CL (Edition K) G1A AFB
INT CL^5 G01D, G01N
Online databases: WPI and CLAIMS

(54) Optical probe calibration

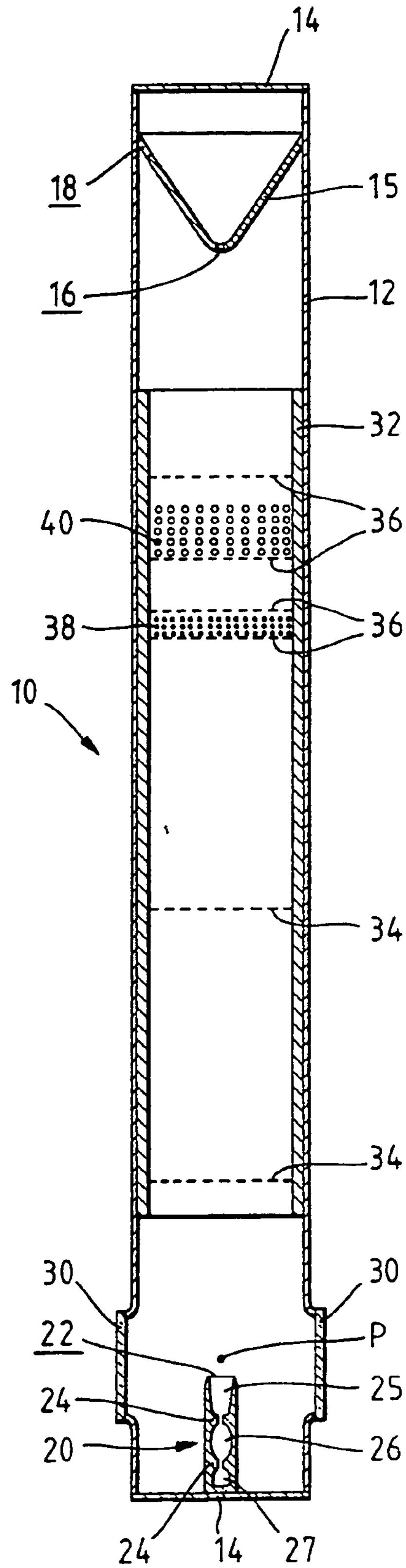
(57) An apparatus is provided to enable the effective size of the probe volume of an optical particle-counting instrument to be calibrated. The apparatus comprises a support such as a tube (12) with a funnel (15) at one end and a collection pot (20) at the other. Windows (30) enable the optical instrument to observe particles in a probe volume at a position (P) just above the pot. The middle of the tube (12) encloses a spaced succession of particle scattering components (34, 36, 38, 40), which spread out a stream of particles falling from the funnel (15) so the falling particles (for example glass spheres) are distributed uniformly over the probe volume (P) and over the pot (20). The pot includes a cavity (26) of known capacity to contain the particles.



BEST AVAILABLE COPY

GB 2 243 213 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.


14
18
15
16
12
32
40
36
38
36
10
34
34
30
30
22
P
25
24
26
20
24
14
27

Optical Probe Calibration

This invention relates to an apparatus and a method for calibrating an instrument for measuring, by an optical technique, particle concentrations or flow rates in a vacuum or a transparent fluid.

The use of laser instruments to measure particle sizes and velocities, for example of fuel droplets from a diesel injector, is known. Such an instrument might incorporate means to cause two laser beams to intersect and so to define a probe volume (in which the beams may interfere); if a particle passes through this probe volume it will scatter light which can be detected. The detected scattered light provides a Doppler signal indicating the speed at which the particle traverses the probe volume, and the scattered light may also be analysed to indicate the size of the particle. The use of such instruments is described in an article by M.L. Yeoman published in "Atom" 368, June 1987.

It will be apparent that such an instrument also enables the number of particles passing through the probe volume to be counted. However, the effective probe volume is different for different sizes of particles, as larger particles may still be detected when near the edge of the intersecting beams where the light intensity is low, whereas a small particle in that location would not scatter sufficient light to be detected. Hitherto there has been no technique available for experimentally calibrating such measurements of particle numbers, and instruments have relied on theoretical estimates of the probe volume.

According to the present invention there is provided a calibrating apparatus comprising a support structure, a funnel near one end of the support structure defining an

orifice through which in operation a stream of solid particles can flow, a container at the other end of the support structure defining a particle-receiving aperture in communication with a cavity of known capacity, means to enable optical observations of particles to be performed in a measurement volume a short distance from the particle-receiving aperture, and means between the funnel and the aperture for spreading out a stream of particles falling from the funnel such that the particles are distributed substantially uniformly over the particle-receiving aperture and over the measurement volume.

In use of the apparatus for calibrating an optical instrument, the support structure is arranged so the funnel is vertically above the container and with the funnel initially containing solid particles. A stream of particles flows out of the orifice (as in a sand-glass), and flows through the spreading means, so particles fall into the particle-receiving aperture. The instrument is arranged so its probe volume is just above that aperture - the probe volume hence being the measurement volume - and is calibrated by counting the number of particles detected by the instrument while the cavity of the container fills up.

The particles might be of opaque or of transparent material, and might be of size between 5 and 200 microns. Preferably the particles are spherical, of bronze, stainless steel, glass, or zirconia for example, and of diameter between 10 and 100 microns; they might all be of substantially the same diameter, for example 60-66 microns or 80-88 microns, or there might be a wide range of sizes, for example a Gaussian distribution of diameters between 10 and 100 microns.

Preferably the support structure is a straight tube or duct which encloses the funnel, the spreading means, and the container. The tube might be closed at both ends, with particles of known size sealed inside it; in this case the funnel is arranged so that the particles can be returned to be inside the funnel by holding the apparatus upside-down. The apparatus can then be used again. The tube might be of length between 0.3m and 0.9m, preferably about 0.5m, and of diameter between 25 and 100mm preferably about 50mm. If the tube is sealed as described above then the optical observations are preferably made through one or more flat transparent windows in the wall of the tube.

The funnel may be of conical shape, or may be curved, and the orifice is preferably of diameter between 0.5 and 2.0 mm. The spreading means preferably comprises a plurality of perforated elements spaced apart along the support structure, for example wire meshes; it is apparent that the perforations must be large enough for the largest particles to pass through freely. Preferably the perforations of an element nearer the funnel are coarser than those of an element nearer the particle-receiving aperture. In a preferred embodiment at least one perforated element comprises a layer of spherical beads (supported on a wire mesh); desirably there are two spaced apart layers of beads, the one nearer the funnel comprising larger beads, for example a layer of 3mm diameter glass beads and then a layer of beads about 1mm diameter.

The container desirably defines a particle-receiving aperture with a sharp edge to ensure a well defined cross-sectional area, and the aperture may be of circular shape and of diameter between 5 and 20mm, preferably about 12mm. The container preferably comprises at least three communicating cavities between which are narrow necks: a funnel-shaped upper chamber, the cavity of known capacity,

and a lower chamber. In use, optical observations are carried out while the level of particles in the container rises from one neck to the next and so filling the cavity of known capacity. The cavity is desirably of sufficient capacity to accomodate several thousand particles, preferably at least ten thousand and possibly millions.

The invention also provides a method of calibrating the probe volume of an optical particle counting instrument utilizing the apparatus defined above.

The invention will now be further described by way of example only, and with reference to the accompanying drawing which shows a longitudinal sectional view of a calibrating apparatus 10 of the invention. The apparatus 10 comprises a glass tube 12, closed at both ends by end plates 14, of length 0.5m and of diameter 50mm; in the figure the tube 12 is shown in its upright position. Near the top end (as shown) is fixed a funnel 15 defining an orifice 16 of diameter 1 mm at its lowest point, and with a return hole 18 near its upper edge. A 50mm tall glass collecting pot 20 is fixed to the middle of the bottom end plate 14. The top of the pot 20 is open, defining a sharp-edged circular aperture 22 of diameter 12mm and the inside of the pot 20 is subdivided by two narrowed necks 24 into an upper cavity 25, a centre cavity 26, and a base cavity 27. The tube 12 also contains some free-flowing sand-like material (not shown) consisting of very small bronze spheres all of diameter between 60 and 66 microns; the centre cavity 26 is large enough to contain over a million of these bronze spheres, and before assembly of the apparatus 10 the actual number needed to occupy the centre cavity 26 between the two necks 24 is determined. (This may be done by measuring the weight of the spheres taken to fill that cavity 26, and comparing this weight to the weight of a much smaller number of spheres which have been

counted). The tube 12 is provided with two plane glass windows 30 diametrically opposite each other, whose centre is level with a point 2mm above the aperture 22.

Between the funnel 15 and the aperture 22 is a particle spreading unit 32 consisting of a metal tube 33, 0.3m long, which fits tightly into the tube 12 and within which are six woven wire meshes : a 125 micron mesh 34 near the bottom of the tube 33 (and about 70mm above the aperture 22), an identical mesh 34 0.1m further up the tube 33, and two pairs of 180 micron mesh 36 the lowest of which is further 0.1m up the tube 33. The gap between the lower pair of meshes 36 is almost filled by glass beads 38 of diameters between 0.6mm and 1.0mm, and the space between the upper pair of meshes 36 is almost filled with glass beads 40 of diameter 3mm.

In use, the apparatus 10 is firstly held upside-down so all the small bronze spheres fall down, through the return hole 18 into the space between the funnel 15 and the end plate 14. The apparatus 10 is then held upright (as shown), with a laser particle monitor (not shown) arranged so its light beams pass through the windows 30 and intersect to define a probe volume at or near the point P directly above the aperture 22, and the scattered light emerges through a window 30 to its detector. A substantially steady stream of the bronze spheres flows out of the funnel 15 through the orifice 16, and is spread out by successive collisions as the stream passes through the meshes 36 and the gaps between the beads 40 and then the beads 38 and finally through the spaced-apart meshes 34. The stream of bronze spheres at the level of the point P is uniform over an area larger than the aperture 22, and is also substantially uniform (ie the spheres are randomly distributed) over the cross-sectional area of the probe volume (which is typically 0.25mm square).

The particle monitor is arranged to count the number of particles (ie the falling bronze spheres) detected during the time in which the centre cavity 26 between the two necks 24 fills with spheres. If the number of spheres needed to fill the centre cavity 26 is N, the number of spheres counted by the particle monitor is n, and the area of the aperture 22 is A, then the effective cross-sectional area a of the probe volume (for particles of this particular size) is given by:

$$a = \frac{A\ n}{N}$$

It will be appreciated that the effective cross-sectional area of the probe volume can thus be calibrated for particles of the same size as the bronze spheres. An alternative calibrating apparatus might have bronze spheres of a different size (for example about 80 microns) or might contain spheres of a wider range of sizes for example between 20 and 100 microns. The range of sizes of the spheres defines the range of particle sizes for which the effective cross-sectional area of the probe volume is calibrated. It will be understood that the spheres might alternatively be of a transparent material such as glass.

Claims

1. A calibrating apparatus comprising a support structure, a funnel near one end of the support structure defining an orifice through which in operation a stream of solid particles can flow, a container at the other end of the support structure defining a particle-receiving aperture in communication with a cavity of known capacity, means to enable optical observations of particles to be performed in a measurement volume a short distance from the particle-receiving aperture, and means between the funnel and the aperture for spreading out a stream of particles falling from the funnel such that the particles are distributed substantially uniformly over the particle-receiving aperture and over the measurement volume.

2. Apparatus as claimed in Claim 1 also including sufficient of the solid particles that in operation the cavity becomes filled.

3. Apparatus as claimed in Claim 2 wherein the particles are spherical and of diameter between 10 and 100 microns.

4. Apparatus as claimed in any one of the preceding Claims wherein the funnel is of conical shape, and the orifice of diameter between 0.5 and 2.0 mm.

5. Apparatus as claimed in any one of the preceding Claims wherein the spreading means comprises a plurality of perforated elements spaced apart along the support structure.

6. A calibrating apparatus for an optical instrument substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

Published [illegible] at The Patent Office, Concept House, Cardiff Road, Newport, Gwent [illegible] Further copies may be obtained from Sales [illegible] Cwmfelinfach, Cross Keys, Newport, NP1 7HZ Printed [illegible] techniques ltd, St Mary Cray, Kent